Workshop 1 – Ecosystem Changes and the Low Salinity Zone
Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan

California Department of Fish and Game
Attachment 1

Question 1.

Scientific and technical information on ecosystem changes and the low salinity zone

The comments herein from the California Department of Fish and Game (Department) do not include specific, comprehensive recommendations for updated flow objectives for the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). We expect to provide such comments to the State Water Resources Control Board (State Water Board) through planned collaborative discussions among state and federal natural resource agencies. These interagency discussions will be substantially based on the March 27, 2012 technical workshop convened by the U.S. Environmental Protection Agency (USEPA) to discuss estuarine habitat in the San Francisco Bay-Delta estuary (Bay-Delta estuary). The Department contributed two workgroup members to the workshop, Randy Baxter and Kathy Hieb.

It is our understanding that the March workshop (Bernstein 2012) was specifically designed to address the information needs of the State Water Board's review and update of the Bay-Delta Plan. The published report from the March workshop is a rich source of information the State Water Board should consider for the Bay-Delta Plan update. The report includes a review of more than 20 key published papers, including topics such as species-specific studies of fish habitat trends, assessment of food web changes and influences, and fundamental physical attributes and processes in the Bay-Delta estuary. The report identifies key points of agreement and disagreement about the low salinity zone and describes available assessment tools and their associated uncertainties.

In the present workshop proceedings you will hear the Department and other entities use terminology that pertains to low salinity in the Bay-Delta estuary that warrants clarification. When we refer to the low salinity zone (LSZ) we are referring to the area of the upper Bay-Delta estuary with a salinity range of 1 ppt to 6 ppt, which is a salinity range considered to be optimum for delta smelt. The LSZ is usually discussed in terms of its geographic location in the Bay-Delta estuary (hence, "zone"). When we use the term low salinity habitat (LSH), we are referring to the salinity range of 1 to 6 *plus* other abiotic and biotic attributes (e.g. lower trophic food organisms) that are characteristic of delta smelt habitat. In other words, habitat consists of physical, chemical, and biological components along with their interactions. The spatial and temporal location of LSH is essential for delta smelt survival. We believe that current observations and futureemerging scientific information supports the contention that delta smelt abiotic and biotic habitat is improved when the LSZ is positioned in Suisun Bay relative to when it is in the western Delta.

Listed Smelt Species are at Risk

Delta smelt (*Hypomesus transpacificus*) as a species, and the Bay-Delta estuary population of longfin smelt (*Spirinchus thaleichthys*), are at risk of extinction. In January 2010 delta smelt were moved from threatened to endangered status under the California Endangered Species Act (CESA). In April 2010 the U.S. Fish and Wildlife Service (USFWS) found that delta smelt warranted endangered status under the federal Endangered Species Act (ESA). In April 2010, longfin smelt was listed as threatened under the California Endangered Species Act (CESA). In April 2012 the USFWS found that the listing of the Bay-Delta Distinct Population Segment (DPS) of longfin smelt was warranted (Federal Register 2012). These listing actions are all subsequent to the adoption of the 2006 Bay-Delta Plan. Since about the year 2000, indices of longfin smelt abundance have been at levels roughly 2% of those observed during the period of the mid-1960s through the mid-1980s. Since 2001 the fall indices of delta smelt abundance have averaged roughly 10% of the average levels observed during the previous 30 or more years. Importantly, of interest for the Bay-Delta Plan update, spring outflows, subsequent fall LSZ conditions and associated drivers all played significant roles in the population viability of the two smelt species (Thomson et al. 2010). Thomson et al. 2010 provides a different analytical approach (using Bayesian model selection with linear regression vs. straight linear regression) that again identified spring flows (modeled as mean March-May X2 location) as being a principal driver of longfin smelt abundance. Longfin smelt abundance shows a long-term decline except during periods of good spring outflow. In addition, the researchers found - at an estuary wide scale - that abiotic factors appeared to have a stronger influence on interannual fish variation, concluding that targeted manipulation of abiotic variables, including flows and exports, could be used to influence fish abundances (Thomson et al. 2010, p. 1445). Mac Nally et al. 2010 (p. 1424) also identified strong data support for large values of spring X2 (upstream location, low outflow) being negatively related to the abundances of longfin smelt, biomass of calanoid copepods (longfin smelt food) during spring and biomass of mysids (another longfin smelt food). The Department's conclusion is that relatively low levels of Delta outflow in spring result in reduced abundance of longfin smelt and reduced biomass of longfin smelt prey organisms.

Elsewhere in this submittal, we identify specific additional information, and provide our assessment of it, regarding flow condition influences on the LSZ and associated listed species. In the next section we provide comments on the status of listed smelt species to emphasize the compelling need for a successful Bay-Delta plan update that will contribute appropriately to species viability and recovery.

Delta Smelt Summer and Fall Flow (X2) Objectives

The Department believes that the State Water Board review and update of the Bay-Delta Plan should include consideration of summer and fall flow objectives to maintain and restore food production and abiotic habitat in the LSZ, which is associated with the quality and quantity of delta smelt habitat. Flow measures to protect the quantity and quality of fall delta smelt habitat were a prominent part of the Delta Smelt Biological Opinion (Smelt BO) for the 2008 USFWS Operational Criteria and Plan (OCAP), and were directly addressed in the Department's November 23, 2010 report entitled "Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta" (CDFG 2010a) (Biological Objectives report) prepared pursuant to Senate Bill X7 1 (2009). Both the 2008 Smelt BO and the 2010 Biological Objectives report contain numerous scientific and technical references relevant to consideration of summer and fall flow protections for delta smelt habitat.

The Bay-Delta Plan review and update process will coincide with the emergence of important new information regarding the effects of summer and fall Delta inflow and outflow. In particular, results of the Fall Low Salinity Habitat studies (FLaSH studies) will become available during the Bay-Delta Plan update process. These studies are coordinated by the Interagency Ecological Program (IEP), and conducted in conjunction with implementation of the Fall X2 component of the Smelt BO Reasonable and Prudent Alternative (RPA). The RPA requires that adaptive management be used to assess the effectiveness of the component. The FLaSH study program is collectively a package of studies designed to increase understanding, and reduce uncertainty, of the effects of X2 position in the Delta and support future management decisions. Preliminary results of the 2011 FLaSH studies were presented on April 20, 2012, during the IEP annual workshop. more recently, from July 31 through August 1, 2012 the Delta Science Program convened an independent science panel to discuss the preliminary results of the 2011 FLaSH studies. Final FLaSH study reports are expected to be available in summer 2013. Based on the Department's informal review of preliminary FLaSH investigations results, we believe the studies are indicating that:

- Summer through fall delta smelt growth improved with the more seaward position of X2.
- The occurrence of a fall plankton bloom may have been facilitated by flow related dilution of ammonium levels.
- High Delta outflows into the fall may disrupt clam reproduction and feeding.
- Persistent higher and cooler spring flows may extend the period when high quality zooplankton (*Eurytemora affinis*) are available in spring, and fall 2011 had slightly higher mysid shrimp and amphipod densities, which delta smelt used as food.

Another source of additional, new scientific and technical information relating to delta smelt and the LSZ likely to emerge during the State Water Board's Bay-Delta Plan review and update process is new or enhanced analysis from the USFWS. During litigation over the fall X2 component of the Smelt BO RPA, the court remanded aspects of the science underlying the RPA back to the USFWS. The USFWS has subsequently been developing analytical improvements, which are anticipated soon. The Department believes these analytical improvements will substantially reduce the uncertainty around the benefits and appropriate specifications of summer and fall X2 objectives.

The Department would also like to draw the Board's attention to the IEP's recent indices of delta smelt abundance. The IEP's 2011 Fall Midwater Trawl (FMWT) index of sub-adult delta smelt abundance was 343, the highest level since 2001, despite the fact that the previous year's index was a very low 29. We believe this simple observation may speak to the strong influence summer and fall LSZ position has on survival of juvenile delta smelt through its effect on the size and quality of delta smelt habitat. The RPA contained in the USFWS OCAP BO includes a component requiring that X2 be maintained at 74 or 81 river kilometers (upstream of the Golden Gate Bridge) in September through October following wet or above normal water years, respectively (additional increments of Delta outflow are required up to the respective fall X2 values in November under specified conditions in the RPA). Although the RPA for the position of X2 in the fall is presently in litigation, wet hydrological conditions in the fall of 2011 naturally achieved the X2 requirement specified, which we believe contributed to the relatively high fall delta smelt abundance index. Water management practices have resulted in Fall X2 being positioned high in the estuary even following wet water-years (e.g., 2006), which may help explain the persistent low delta smelt indices of the pelagic organism decline (POD) years.

The relatively high 2011 FMWT index was followed by a promising spring 2012 ("20 nm") index of larval production, followed by a poor index of summer 2012 juvenile abundance (Summer Townet Survey Index). These three major indices of delta smelt abundance are published shortly after survey are completed and will be available on an ongoing basis as the Bay-Delta Plan review and update process proceeds.

Delta Flow Remains an Important Driver of Longfin Smelt Abundance

As a species listed as threatened under the CESA and a candidate species[1] under the ESA, special consideration and evaluation should be given to ensuring that the necessary protections are provided for longfin smelt. It has long been recognized that the annual production of longfin smelt is closely and positively associated with the level of Delta outflow during the winter through spring months. Although the response of the population to outflow changed after the mid-1980s introduction of the over-bite clam (*Potamocorbula amurensis*), and further changed during the recent POD period (i.e., post-2002 for longfin smelt), there is considerable recent evidence that the winter through spring position of X2 (or magnitude of outflow) remains an important driver of production. Two recent modeling studies (Mac Nally et al. 2010 and Thomson et al. 2010) provide two different analytical approaches that both conclude that spring flows were the principal drivers, among the variables examined, of longfin smelt abundance. Furthermore, Mac Nally et al. (2010) found that large values of spring X2 (upstream location; low flows) resulted in low spring biomass of Calanoid copepods (a longfin smelt food) and low biomass of mysids (another longfin smelt food). The Department discussed this flow and longfin smelt abundance association, with appropriate references, in the 2010 Biological Objectives and Flow Criteria report (CDFG 2010a, starting page 32). The subject is also addressed in the Water Board's August 2010 "Development of

[1] https://www.federalregister.gov/articles/2012/04/02/2012-7198/endangered-and-threatened-wildlife-and-plants-12-month-finding-on-a-petition-to-list-the-san

Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" report beginning on page 66 (SWRCB 2010), and in the Department's related submission at the Water Board's 2010 workshop (CDFG 2010b, pp. 9-10).

The primary measures of longfin smelt abundance used in discerning the flow and abundance relationships are indices derived from the IEP Midwater Trawl and San Francisco Bay Study surveys conducted by the Department (Baxter et al. 2010., figure 27) The 2010 Biological Objectives and Flow Criteria report includes relevant survey indices through fall 2007. A recent report regarding the POD decline (Baxter et al. 2010) updates the discussion of the flow and abundance relationship using indices through fall 2009. This report also contains recent assessments of how flow influences the vulnerability of smelt at various life stages to entrainment at the State and Federal Water Project export facilities. For the purposes of the Bay-Delta Plan review and update, new indices and updated flow and abundance associations will be available using indices derived from the FMWT through fall of 2012. The FMWT indices of abundance for 2010 (a "below normal" water year) and 2011 (a "wet" water year) were 191 and 477, respectively, indicating a continued statistically significant flow and abundance association.

The information referenced above addresses how the level of longfin smelt production varies with flow, and thus can be used to assess production levels associated with existing and proposed Bay-Delta Plan objectives. However, understanding the relationship between flow and production does not directly address the more important question of the amount and timing of flow necessary to sustain the longfin smelt population or contribute to its recovery. During the course of the Bay-Delta Plan review and update process we expect new information to emerge on this more important question. Specifically, promising preliminary analysis is being conducted that seeks specifically to remove clam introduction and POD effects on adult stock from abundance trends and, thus, identify the winter through spring flow levels required to achieve year-over-year positive stock-recruitment trends that would lead to positive population growth. This same preliminary analysis may enhance our understanding of the relative importance of flow during different months of the winter through spring period.

Collectively, the additional information available during the Bay-Delta Plan review and update process will warrant consideration of modifying specific Bay-Delta Plan objectives associated with longfin smelt protection. In addition to updating and optimizing winter through spring flow objectives related to the position of X2, consideration should be given to adding winter through spring objectives for Old and Middle River (OMR) flows to reduce the impact of entrainment at the State and Federal Water Project water export facilities. OMR objectives in the Bay-Delta Plan should be consistent with section 5 of the Department's longfin smelt Incidental Take Permit[2] issued to the Department of Water Resources in 2009 (CDFG 2009).

[2] http://www.dfg.ca.gov/delta/projects.asp?ProjectID=LONGFINSMELT

Outflow Criteria for Species Inhabiting the Lower Estuary

The State Water Board's June 22, 2012 public notice announcing the informal workshops associated with Bay-Delta Plan review and update does not explicitly address species primarily inhabiting the lower San Francisco Estuary or those whose habitat extends into higher salinities downstream of the LSZ. Some of these species exhibit strong responses to Delta outflow, and should be considered during the review and update process. The Bay-Delta estuary is a complex ecosystem with a continuum of habitats ranging from freshwater to marine. The public notice suggests a strong focus on aquatic species and supporting habitats found primarily within and above the LSZ. These habitats and species are an appropriate subject of strong focus for the Bay-Delta Plan update, but it should not lose sight of the other native aquatic and terrestrial species which also are sustained by this diverse ecosystem and would be affected by Delta outflow objectives established by the State Water Board.

Estuarine species that commonly occupy habitat downstream of the LSZ and may be influenced by flow objectives established during the Bay-Delta Plan update, include starry flounder (*Platichthys stellatus*), the bay shrimp (*Crangon franciscorum*), and Pacific Herring (*Clupea pallasii*). The distribution and abundance of one species in particular, the marine-oriented northern anchovy (*Engraulis mordax*), has been dramatically impacted by the reduced productivity within the LSZ (Kimmerer 2006) and should be considered during the Bay-Delta Plan review and update process. Biological goals and flow objectives for some of these species may overlap or coincide with species of special concern (e.g. delta smelt and longfin smelt) and would thereby benefit from protective conditions, as well.

The Department's 2010 Biological Objectives and Flow Criteria report addresses the flow needs of key lower estuary species. Additional information available for the Bay-Delta Plan review and update process include recent IEP distribution information and abundance indices.

Question 2.

Framework for Adaptive Management

Uncertainty is pervasive in ecosystem management, given that the underlying biological and physical processes have inherently fluctuating components that will never be fully explained, predicted, or controlled (Parma et al. 1998).

Uncertainty in this context may include: 1) the inability to predict the future state of dynamic systems; 2) the degree to which future conditions depend on unpredictable or unforeseen external drivers; 3) incorrect or incomplete information about underlying processes that make predicting outcomes difficult; or 4) disagreement about the underlying processes based on alternative interpretations of data. Uncertainties in ecosystem management are compounded by uncertainties related to future conditions such as climate change, population growth, water supply, and likelihood of catastrophic earthquakes.

The uncertainty about management impacts is often expressed as disagreements among stakeholders who have differing views about the direction and magnitude of resource change in response to management actions (Williams et al. 2009). These uncertainties potentially degrade management performance and contribute to acrimony in the decision making process (Williams et al. 2009). An adaptive management approach provides a structured process that allows for taking action under uncertain conditions based on the best available science, closely monitoring and evaluating outcomes, and re-evaluating and adjusting decisions as more information is learned. Through such an approach, understanding of both the resource and its management can be enhanced over time.

Adaptive management is defined in the 2009 Delta Reform Act (Water Code Section 85052) as "a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives".

The State Water Board previously noted that "[a] strong science program and a flexible management regime are critical to improving flow criteria. The Water Board should work with the Delta Stewardship Council, the Delta Science Program, Bay Delta Conservation Plan (BDCP), the IEP, and others to develop the framework for adaptive management that could be relied upon for the management and regulation of Delta flows" (SWRCB 2010). The Department of Fish and Game agrees with these statements and provides the following information as the first step towards helping to facilitate such a process.

A rich literature regarding adaptive management exists and serves as the basis for the approach identified below (e.g., Holling 1978, Walters 1986, Walters and Holling 1990, Christensen et al. 1996, Stanford and Poole 1996, Parma et al. 1998, CALFED 2000, Atkinson et al. 2004, Abal et al. 2005, Healey 2008, Dahm et al. 2009, Williams et al.

2009, National Research Council 2011, Delta Stewardship Council 2012). While differences among the various frameworks exist, they generally contain three broad phases: *Plan*, *Do*, and *Evaluate and Respond*. The Department recommends that the Water Board consider the three phase (nine-step) adaptive management framework described in the Final Staff Draft of the Delta Plan (Appendix A, Delta Stewardship Council 2012) and depicted in Figure 1.

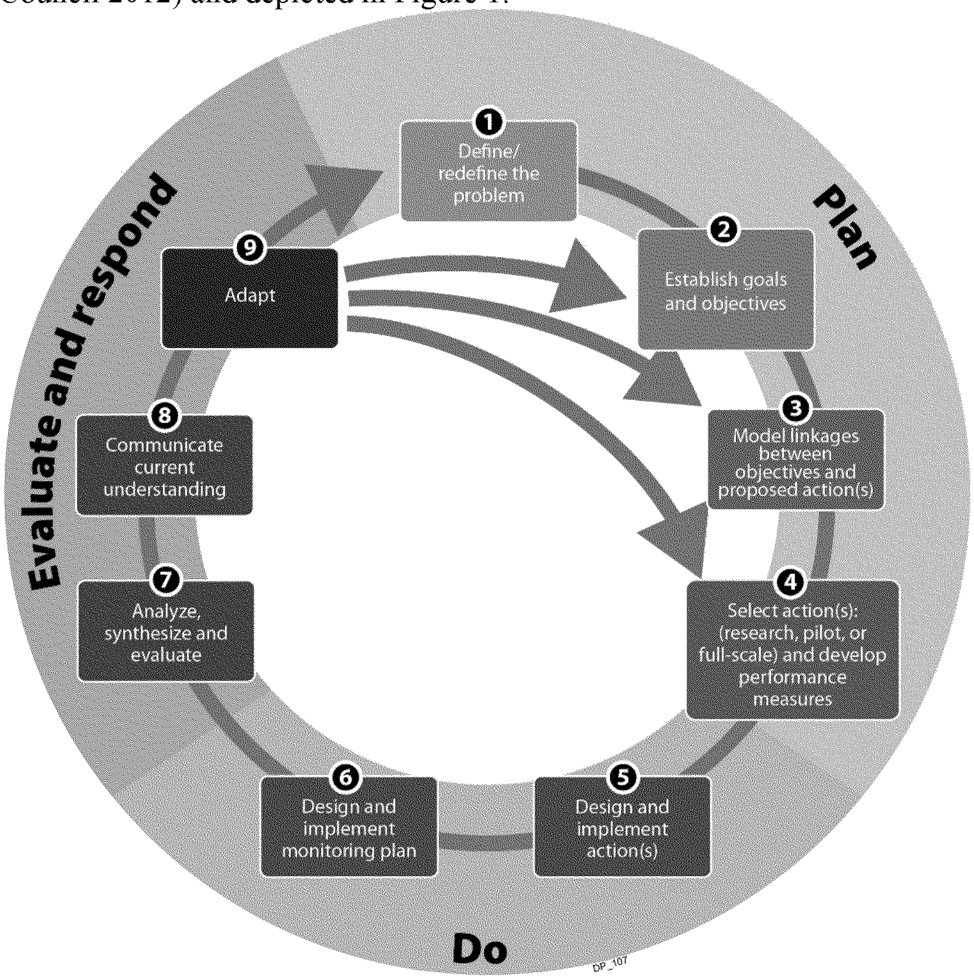

Figure 1: A Three Phase (Nine-step) Adaptive Management Framework (Source: Final Staff Draft Delta Plan (Delta Stewardship Council 2012). The shading represents the three broad phases of adaptive management (*Plan*, *Do*, and *Evaluate and Respond*), and the boxes represent the nine steps within the adaptive management framework. The circular arrow represents the general sequence of steps. The additional arrows indicate possible next steps for adapting (for example, revising the selected action based on what has been learned).

The Delta Independent Science Board (ISB) has noted that the Delta Plan provides an excellent description of adaptive management and that it represents an effective synthesis of the existing literature that is presented in a manner that is instructive (Norgaard 2011). The requirement for the Delta ISB to provide oversight of scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs (Water Code § 85280(a)(3)) provides additional justification for the adoption of a consistent approach to adaptive management and associated terminology.

In the absence of explicit and measurable management objectives, adaptive management is not feasible (Williams et al. 2009). Delta Vision and the resulting legislation (Delta Reform Act) have helped to solidify California's vision and goals with respect to ecosystem health and water supply reliability (i.e., co-equal goals). Within that construct, the Department recommends that the State Water Resources Control Board, in collaboration with stakeholders, define the management goals and objectives specific to Phase 2 of the Comprehensive Review of the Bay-Delta Plan. The goals and objectives articulated in the CALFED Ecosystem Restoration Program's (ERP) *Strategic Plan for Ecosystem Restoration* (CALFED 2000), the Department of Fish and Game's *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta* (CDFG 2010a), the Water Board's *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem* (SWRCB 2010), and the U.S. Bureau of Reclamation's *Draft 2012 Plan for Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability* (USBR 2010) serve as useful point of reference in the effort to develop management objectives for Phase 2 of the Comprehensive Review of the Bay-Delta Plan.

Clearly articulated conceptual models that specify key state variables, describe their dynamic interrelationships, and project the consequences of alternative management actions are a key component of adaptive management (Walters 1986). Models are extremely valuable for formalizing the link between objectives and proposed actions to clarify how and why each action is expected to contribute to objectives. They also provide a venue through which to identify areas of uncertainty, assess the likelihood of success, evaluate tradeoffs associated with different management actions, and define monitoring needs. A formal approach to the development of conceptual models was created under the auspices of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), a component of the ERP. The fundamental approach to modeling, implemented through this process, is a "driver-linkage-outcome" format that uses deterministic models of ecosystem components linked together with cause-and-effect relationships of interacting variables and outcomes. Two types of conceptual models have been generated through the DRERIP process: species life history models and ecosystem models. The ecosystem models have been categorized into processes, habitats, and stressors. Additional information regarding these conceptual models, and the models themselves, is available online at: http://www.dfg.ca.gov/ERP/conceptual_models.asp. The IEP has developed a suite of conceptual models over the course of the pelagic organism decline (POD) investigation that revolve around natural and anthropogenic drivers that affect ecological change such as the observed pelagic fish declines (Sommer et al. 2007, Baxter et al. 2010, U.S. Bureau of Reclamation 2012). Additional conceptual and quantitative models are being developed by other agency, academic, and NGO scientists for use in improving understanding of the Delta and upstream ecosystems. There remains a particular need for the development of effective life cycle models for key fish species.

Given the fundamental complexity and dynamic nature of the estuary, there is an ongoing need for well-conceived, strongly supported, and collaboratively conducted scientific monitoring and research. The Interagency Ecological Program (IEP) has a demonstrated tradition of providing high quality ecological information and scientific leadership for use in management of the San Francisco Estuary, including the Delta. This multi-agency collaboration will continue to be important for addressing scientific uncertainties and evaluating multiple drivers that influence conditions within the estuary.

It will be critical to monitor the implementation of the updated water quality objectives to gauge how the ecosystem responds to these management interventions. The monitoring activities should be question driven and explicitly designed to inform decision making pertinent to the adaptive management process. For example, this may include evaluating the effectiveness of management actions (progress towards achieving management objectives), determining the status of a particular resource, increasing understanding of resource dynamics via comparison of predictions against survey data, or generating information needed to enhance and develop models of resource dynamics (Williams et al. 2009).

Changes to the existing monitoring and special studies program should be predicated on a review of the Environmental Monitoring Program (existing requirements are stipulated in Table 7 of the 2006 Bay-Delta Plan) and other relevant on-going monitoring efforts (e.g., Spring Kodiak Trawl, Tow Net Survey, FMWT Survey) in the context of the State Water Board's goals and objectives and the updated water quality objectives. In its comments to the State Water Board concerning the Supplemental Notice of Preparation and Notice of Scoping Meeting for the Comprehensive Review, dated 2 May 2012, the Department of Fish and Game identified a number of potential changes to the existing monitoring and special studies program that should be considered during this process. Independent expert review of the updated monitoring and special studies program, prior to initial implementation and at regular intervals (e.g., every five years) thereafter, will help to ensure that the plan is of sufficient robustness and scientific quality to serve its intended purposes.

Implicit in the adaptive management framework is the expectation that the consequences of management actions will be monitored and assessed to determine whether and how such actions are having the intended effects. The evaluation should address questions, such as: how have conditions changed, have they changed in expected ways, and what might have caused deviations from the expected trajectory (Dahm et al. 2009). These activities are critical in order to convert survey data into information that can inform decision making and are essential steps supporting the feedback loops that are foundational components of adaptive management. As such, sufficient resources need to be allocated to support analysis, synthesis and reporting.

It is worth noting that much work has been done and is currently on-going with respect to the topic of adaptive management within the Delta and supporting watersheds. For example, an adaptive management program was implemented through CALFED (2000) and another is currently being implemented for fall outflow (U.S. Bureau of Reclamation 2012), pursuant to the requirements of the U.S. Fish and Wildlife Service's (2008) biological opinion. In addition, adaptive management is being incorporated into a number of current planning efforts, including the review and update of San Joaquin River flow objectives (SWRCB 2011), Delta Plan (Delta Stewardship Council 2012), BDCP, and FloodSafe. An important effort will be to seek opportunities to integrate these efforts to the full extent practicable. The National Research Council's report on *Sustainable Water and Environmental Management in the California Bay-Delta* (NRC 2012a) highlights four approaches that provide structured, transparent procedures for decision-making and rationalization of decisions in complex situations (refer to Appendix F). Decision-support tools, such as those described by the NRC (2012a), are likely to have great utility during the Comprehensive Review and subsequent implementation of the revised water quality objectives, given the complexity of the issues being addressed and the diverse interests of the stakeholders.

As a cautionary note, despite its intuitive appeal, the application of adaptive management has been far less successful than one would expect (Walters 2007). Walters (2007) identified three main factors contributing to the widespread implementation difficulties in adaptive management programs: 1) failure of decision makers to understand why they are needed; 2) lack of leadership for the complex process of implementing an adaptive approach; and 3) inadequate funding for the increased ecological (and often economic) monitoring needed to successfully compare the outcomes of alternative policies. High implementation costs and the large number of factors involved also often hinder the application and success of adaptive management (NRC 2011).

In addition, not all decisions can or should be adaptive. For example, Doremus (2012) has argued that in order for adaptive management to be undertaken, the following conditions must occur: (1) there must be an information gap that is important to management choices; (2) good prospects for learning at an appropriate time scale compared to management decisions; and (3) opportunities adjust the initial decision over time in response to new information. With respect to the review and update of the Bay-Delta Plan, the first condition clearly exists, and the second condition seems likely to exist provided the monitoring and special studies program is designed well. The third condition, concerning opportunities for adjustments is more problematic. For example, if reliability of water diversions is a goal, the flexibility to manage adaptively may be significantly constrained (National Research Council 2011, 2012a). The ability to adapt in response to new information and how such adaptation will be accomplished warrants thoughtful consideration and a clear description of how it will be addressed. So while adaptive management is necessary, it is not easy, quick, or inexpensive to implement and will require a significant investment in planning and development on the part of the State Water Board and interested stakeholders. The Department looks forward to being a partner in the effort to develop a well-designed and comprehensive adaptive management program.

Tools and Monitoring Needs to Address Invasive Species

Nonnative plant and animal species have been continuously introduced into California's wildlands and waterways for over 200 years. These species come from within the United States and all over the world. Many nonnative species have successfully established self-sustaining, naturally reproducing populations throughout California, while others have failed to establish or have limited ranges. Successful nonnative species are considered to be invasive when they:

1) threaten the diversity and abundance of California native species through competition for resources, predation, parasitism, interbreeding, transmitting diseases, or physically or chemically altering native species' habitat; and
2) create human health and safety issues and/or negatively impact the local and state economy by obstructing navigable waterways, damaging water supply infrastructure, impeding water delivery, weakening flood control structures, reducing water quality, impairing recreational uses, harming crops and livestock, and diminishing game and sportfish populations (CDFG 2008).

Over 600 aquatic invasive species currently exist in California (CDFG 2008); over 200 of these aquatic invaders are present in the Bay-Delta estuary (Cohen 1998). Without proper management, aquatic invasive species could undermine the ecosystem and the consequences could be deleterious for the entire state of California.

A major management tool to *prevent* introductions of invasive species is through vector control. This means regulation of commercial and recreational watercraft. Commercial shipping, commercial fishing, and recreational watercraft are the leading vectors of introductions of new nonnative species to California. The State Lands Commission regulates ballast water for all vessels weighing over 300 tons that arrive at California ports and places after departing from ports or places within the Pacific Coast Region[3]. Common vessels weighing more than 300 tons include containerships, tanker vessels, bulk carriers, cruise ships, car carriers, general cargo ships, and to a lesser extent large barges, research vessels, and floating cranes or dredges. Generally, the farthest upstream point vessels of this capacity travel, and therefore ballast water is regulated, is the ports of Sacramento and Stockton (C. Scianni, personal communication, 8 August 2012). Thus, due to the 300 ton minimum, commercial and sportfishing boats and recreational watercraft are not regulated for ballast water in the entire estuary, nor are watercraft upstream of the ports of Sacramento and Stockton regulated. This gap needs to be addressed if a vector control strategy is to succeed in controlling the introductions of invasive species in the estuary.

Some water managers across the state are implementing inspection programs to ensure invasive species are not introduced into lakes or reservoirs and water systems from watercraft, a common vector for species introduction. Additionally, the California Department of Food and Agriculture performs roadside inspections of incoming

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[3] The Pacific Coast Region means all coastal waters on the Pacific Coast of North America east of 154°W longitude and north of 25°N latitude, exclusive of the Gulf of California; coastal waters means estuarine and ocean waters within 200 nautical miles of land or less than 2,000 meters deep, and rivers, lakes, or other water bodies navigably connected to the ocean, per Article 4.6, Chapter 1, Division 3, Title 2, CCR.

watercraft at several boarder inspection stations in an effort to ensure aquatic invasive species are not being brought into California. These are important programs and may be effective at the locality of the specific water bodies, water systems, or inspection stations, but these programs cannot ensure prevention of the introduction of invasive species statewide. Furthermore, there are no active watercraft inspection programs in the Bay-Delta estuary.

In an effort to help prevent the introduction of invasive species in the estuary, especially from watercraft that is not regulated by the State Land Commission and from watercraft that is located above the ports of Sacramento and Stockton, the State Water Board could include in the Bay-Delta Plan, an objective to prohibit the discharge of ballast, hull, and other nuisance water from watercraft under 300 tons anywhere in the Bay-Delta ecosystem.

A major management tool that can be used to *control* populations of invasive species is regulation of flow regimes. Water flows are considered by many experts to be the master ecological variable in the estuary. Native species in the estuary are adapted to and depend on a flow regime that provides seasonal and spatial variability in flows, water quality, salinity, and temperature (Mount et al. 2012). The altered flow regime of the estuary that exists today provides less variability for native species and more stable conditions for nonnative invasive species. As a result, populations of native species in the estuary, most notably fish (e.g., Chinook salmon, sturgeon, delta smelt, longfin smelt, etc.) are in decline and nonnative invasive species (e.g., Asian and overbite clams, largemouth bass, aquatic plants, etc.) are thriving. In an effort to control nonnative species, a flow regime should be designed for the estuary that resembles the historical flow regime which provides flow and habitat conditions favorable for native species and unfavorable to non-native invasive species.

<u>Uncertainty and Changing Circumstances from Climate Change</u>

Climate change is a major challenge to the conservation of California's natural resources including the Bay-delta estuary. Projected changes in temperature and precipitation regimes will impact species and their habitats through their effects on flooding, snowpack, streamflow, droughts, and wildfire. While seawalls and revetments may provide protection against a certain set of wave and sea-level conditions, if seal level increases substantially, the original freeboard will be gradually exceeded and overtopping will become more frequent (NRC 2012b). Salt water intrusion into freshwater resources and inundation resulting from coastal flooding may further pollute aquatic habitats having severe adverse effects on terrestrial and marine ecosystems alike.

Current legislation and polices addressing climate change include:

- The California Global Warming Solutions Act of 2006 (Assembly Bill 32)
- Executive Order S-3-05
- Senate Bill 97 (2007)
- Executive Order S-13-08

- State of California Sea-Level Rise Interim Guidance Document (2010)
- Resolution of the Ocean Protection Council on Sea-Level Rise (2011)

The Department's Climate Change Vision (CDFG, 2011) explains its goal of minimizing the negative effects of climate change on the state's fish, wildlife and habitats and illustrates the Department's current effort to use adaptive management to ensure a cohesive and strategic approach for developing actions that will provide measureable outcomes. Thethe vision models linkages between climate goals and objectives and natural resources planning, such as the Department's Wildlife Action Plan. As new climate change data and information are generatedother programs and climate change workgroups in the state use the information in their own ongoing planning and adaptive management processes. Such synthesized analysis and conclusions are often then communicated to the general public as part of public review processes for revising climate change strategies or through pre-determined actions based on performance measures, which may lead to different adaptation management planning activities. The California Natural Resource Agency has already begun the process for updating its Climate Adaptation Strategy for 2012 through this adaptive management cycle that started with the 2009 Adaptation Strategy. The Department recommends the State Water Board review these updates and materials as they become available to help inform the Bay-Delta Plan update.

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